Journal of Aging Science
ISSN: 2329-8847

Silva et al., Aging Sci 2015, 3:2
DOI: 10.4172/2329-8847.1000137

Research Article Open Access

Influence of Inspiratory Muscle Training on Changes in Sleep Architecture in Older Adult - Epidoso Projects

Mayra dos Santos Silva[1*], **Luiz Roberto Ramos**[1], **Sergio Tufik**[2], **Sonia Maria Togeiro and Guiomar Silva Lopes**[1]

[1]*Departamento de Medicina Preventiva, Universidade Federal de São Paulo, São Paulo, Brazil.*

[2]*Disciplina de Medicina e Biologia do Sono, Departamento de Psicobiologia, Universidade Federal de São Paulo, São Paulo, Brazil.*

***Corresponding author:** Mayra Dos Santos Silva, Departamento de Medicina Preventiva, Street Eduardo Cantor, 256 CEP: 02979-180 Sao Paulo, Brazil, Tel: 55 11 36612805; Fax: 55 11 32281576; E-mail: mayra.santos@ig.com.br

Received date: June 26, 2015; **Accepted date:** July 16, 2015; **Published date:** July 23, 2015

Abstract

Background: Senescence is accompanied by changes in sleep parameters including fragmentation and increased abnormal respiratory events (apneas/hypopneas obstructive and central) with hypoxemia.

Objective: This project aims to investigate the influence of inspiratory muscle training through the Threshold® on sleep disorders.

Methods: The study involved the participation of 38 older adult volunteers of both genders with sleep disorders confirmed by polysomnography. Chosen patients underwent laboratory evaluation, cardiorespiratory assessment and evaluation of sleep, forming two groups: control group (Threshold® unloaded) and experimental groups (Threshold® loaded). The study lasted 8 weeks and frequency of 7 times per week, lasting 60 minutes each session.

Results: Showed a decrease in the fragmentation sleep and apnea/hypopnea index.

Conclusion: These results made us suggest that inspiratory muscle training can be a good help in the treatment of sleep-related breathing disorders.

Keywords: Aging; Inspiratory training; Sleep disorders

Abbreviations

SCN: Suprachiasmatic Nucleus; CGA: Comprehensive Geriatric Assessment; IPAQ: International Physical Activity Questionnaire; AHI: Apnea-Hypopnea Index; BMI: Body Mass Index

Introduction

Aging is associated with physiological changes, resulting in changes in the quality and quantity of sleep, such an increased superficiality and fragmentation of sleep [1]. Coupled with a number of sleep disorders that either emerge or exacerbate with age, the effects of poor sleep often result in an overall worsening of quality of life [2].

Sleep architecture goes through the following changes with aging: reduction in the duration of stages 3 and 4; an increase in the latency period at the onset of sleep; reduction in both total duration of REM sleep as in total sleep time; the greater number of transitions from one stage to another and to wakefulness; increased respiratory problems during sleep; increase of nocturnal myoclonic activity [3].

The origins of the changes in the quality of sleep are related to changes in the neurological transmission of optical information from the retina to central markers (suprachiasmatic nucleus-SCN), which lose their ability to respond to information, changing the sleep-wake-cycle [4,5]. There are also other factors that contribute to sleep problems in old age, such as pain or physical discomfort; respiratory problems; drug use; nocturnal unrest; environmental factors and emotional discomfort [6].

Chronic sleep restriction is associated with the risk of developing obesity, glucose intolerance, hypertension, diabetes, metabolic syndrome and heart disease, leading to an increase in mortality [7]. The mechanisms involved in changing the glucose metabolism and sleep patterns may be related to a decrease in the effectiveness of the hypothalamic-pituitary-adrenal axis, favoring alterations of the sleep-wake cycle [8]. The hypothesis created to try to explain the correlation between sleep pattern alterations in aging and insulin resistance suggests that sleep deprivation could reduce antioxidant defenses, given that normal sleep removes the reactive oxygen species produced in various tissues during wakefulness, thus maintaining the protection against oxidative stress [9].

A sedentary lifestyle has been observed to be related to changes in the quality of sleep. It is possible that sleep disorders associated with metabolic dysfunctions related to aging are in part related to a sedentary lifestyle [10]. As a result, between 2002 and 2004 the Diabetes Prevention Program [11] and American Diabetes Association [12] recommended that older people should practice 150 minutes of moderate physical activity each week, such as swimming, dancing or walking. They emphasized that aerobic training could be an important influence on glucose control and insulin sensitivity.

More recently, resistance exercises have been employed as a therapeutic procedure in the treatment of chronic diseases, in the reduction of risk factors for cardiovascular diseases and in the improvement of insulin sensitivity [13].

Resistance, breathing and relaxation exercises have also proven to be beneficial in relation to sleep, according to the American Sleep Disorders Association [14], reducing pre-sleep anxiety and improving chronic primary insomnia [13]. Elderly who were submitted to physical training for 6 and 12 months, respectively, showed a reduction in nighttime awakenings, with a tendency to increase total sleep time, a reduction in sleep latency and improvements in the glucose metabolism [15].

It is worth emphasizing, however, that older people are often faced with limitations when it comes to regular physical activity as a result of chronic osteoarticular diseases and obesity [16,17]. In these cases, inspiratory muscle training can be an effective and compensatory alternative to overcome motor barriers [18,19].

Inspiratory muscle training can be carried out with Threshold®, a device that has a flow independent, single direction valve and that provides a constant and specific pressure for inspiratory muscle strength and resistance training, regardless of whether the patients breathe fast or slowly. When the patient's breathe in through the Threshold® IMT, a spring valve provides resistance to the respiratory muscles.

When the Threshold® expiratory device is used, the expiratory muscles are activated, more specifically, under videofluoroscopy the hyoid bone was observed to rise vertically from its rest position, and the velopharyngeal port to close with the air of the user to the device [20]. The importance of the hyoid bone lies in its function in relation to the masticators, respiratory and phonoarticulatory systems, since it provides a connection for muscles, ligaments and fascia of the pharynx, jaw and skull, which means it may be effective in the treatment of breathing disorders during sleep [21].

Before all the benefits demonstrated by breathing exercises asleep, became interested in to investigate the influence of inspiratory muscle training through the Threshold® on sleep disorders.

Materials and Methods

Study description

The study consisted of clinical, analytical, and controlled assays. The outcomes were evaluated by blinded investigators.

Participants

The study included a cohort of 38 older adults over 60 years from the Center for the Study of Aging at UNIFESP (Epidoso), with some alteration of sleep, according to evaluations performed with the Comprehensive Geriatric Assessment tools (CGA). The CGA is a questionnaire with a series of medical evaluations with several health professionals (physician, nutritionist, physical educator and psychologist). The mean age was 73.68 years (range: 64 to 89), with female predominance (55%) and high BMI (27.36).

Exclusion criteria

Individuals with severe degenerative diseases, practitioners of regular physical activity (more than 3 times per week lasting 60 minutes per session or with an energy expenditure of 2000 k/cal, as assessed by IPAQ 6 questionnaire), current smokers and ex-smokers who stopped smoking at least 6 months prior to the study; those with a prior history of lung disease, or patients with cognitive impairment that would hinder their understanding of the procedure (assessed with the Mini Mental State Examination questionnaire), were excluded.

Ethical approval

All chosen participants signed a formal consent. This study covered the bioethics principles of autonomy, beneficence, veracity, and confidentiality. The study was approved by the Research Ethics Committee of the Federal University of São Paulo.

Material and procedure

Patients underwent polysomnography examination for the assessment of sleep discords held at the Sleep Institute (Department of Psychobiology) recording the entire night and using the polygraph of the brand Sleep Analyzing Computer SAC Version 8.1 (Oxford Instruments Inc.). The examination included electroencephalogram, electrooculogram, eletromiogramasubmentoniano and tibial, electrocardiogram, record of the oronasal flow, thoracoabdominal movement, record of both snoring and body position as well as oximetry. It was deemed insomnia objective when sleep efficiency was 85% and wakefulness was 15%. Also, objective apnea was deemed polysomnographic diagnosed when the apnea-hypopnea index (AHI) of polysomnography was higher or equal to five events per hour. Restless legs occurrence to polysomnography was characterized as the movements were recorded more than five times per hour.

Patients filled out the Epworth sleepiness questionnaire at the laboratory and subjectively informed the amount of hours slept.

After initial evaluation, individuals were divided into 2 groups: a control group that trained with the Threshold® device with minimal load, and an intervention group that performed respiratory muscular training during the first session of each week at inspiratory loads of 40% of the PImax. The training program was performed during 8 weeks, with both groups performing 30-minute daily sessions (6 sessions/week at home and weekly at the clinic). Training with Threshold® device was performed with a nasal clip in the seated position using diaphragmatic breathing technique. A diary was supplied to patients to record schedules, training accomplishments, and assiduity to the 2 months training (80% of patients maintained the diary throughout the experiment).

Statistical analysis

Data were analyzed using SPSS version 19.0. For the comparison between groups, means were analyzed using univariate analysis for repeated measures of variance (ANOVA). For all tests, $p<0.05$ were considered statistically significant.

Study limitations

Threshold does have benefits, but its use has limitations, as the maximum load setting is 41 cmH_2O. Some participants could have trained with loads greater than 41 cmH_2O, but the equipment could not gauge above this value.

Results

Table 1 shows the characteristics of study patients. It is observed aged between 60-85 years, were randomly divided into two groups:

Citation: Silva MD, Ramos LR, Tufik S, Togeiro SM, Lopes GS (2015) Influence of Inspiratory Muscle Training on Changes in Sleep Architecture in Older Adult - Epidoso Projects. Aging Sci 3: 137. doi:10.4172/2329-8847.1000137

control (n=20) and experimental (n=18). The two groups were homogeneous, as there were no significant differences between the means of the variables analyzed. It is observed that the average age was 74.10 years for the control group and 71.78 for the experimental group; the mean body mass index was in both groups of around 27, whose value is considered overweight. Waist circumference and neck circumference are within the proposed normal values.

Variable	Control (N:20)	Experimental (N:18)	P*
Age (years)	74.10 ± 5.44	71.78 ± 5.44	0.138
Weight (kg)	70.42 ± 9.84	73.38 ± 19.21	0.666
Height (cm)	1.60 ± 0.092	1.62 ± 0.071	0.214
BMI (Kg/m^2)	27.58 ± 4.08	27.79 ± 5.71	0.184
Cir Abdominal (cm)	95.87 ± 9.45	96.61 ± 12.48	0.319
Cir Neck (cm)	38.80 ± 4.22	38.72 ± 2.82	0.387
IP Max (cmH_2O)	68.75 ± 24.27	62.78 ± 16.73	0.167
EP Max (cmH_2O)	96.00 ± 20.87	78.89 ± 24.22	0.773
Threshold Pressure (cmH_2O)	30.70 ± 9.52	28.83 ± 7.03	0.721
Charging Time (min)	8.50 ± 4.87	7.56 ± 3.69	0.112
Cortisol (ug/dL)	15.49 ± 4.46	14.54 ± 5.19	0.29

Date represented as means ± SD. P<0.005

BMI: body mass index; IP: Inspiratory pressure; EP: expiratory pressure

Table 1: Characteristics of study patients.

Table 2 shows the results after the intervention with respect to sleep variables.

The Epworth Sleepiness Scale remained within normal limits and the subjective index overestimated sleep (>1). The latency to REM sleep remained increased, decreased total sleep time, as well as the efficiency of sleep in both groups.

It was noted, however, that the inspiratory muscle training influenced the following variables: arousal index (p: 0.002); AHI (p: 0.001), apnea (p: 0.007), desaturation during REM sleep (p: 0.001) and desaturation during NREM sleep (p: 0.001), but the control group had increased arousal index and apnea index/hypopnea.

Variables	Control (N: 20)		Experimental (N: 18)		p group	p time	p interaction
	Before	After	Before	After			
Epworth	6.75 ± 4.52	7.75 ± 4.70	5.39 ± 2.74	4.72 ± 3.46	0.081	0.699	0.59
Overnight hours referred (min)	6.45 ± 1.11	6.27 ± 1.04	6.13 ± 1.30	6.22 ± 1.55	0.59	0.846	0.586
Sleep perception index	1.45 ± .675	1.37 ± .480	1.32 ± .549	1.22 ± .490	0.392	0.324	0.884
Sleep onset latency (min)	32.23 ± 33.68	34.56 ± 30.89	29.97 ± 34.76	22.75 ± 24.59	0.425	0.643	0.367
REM latency (min)	113.07 ± 13.83	109.78 ± 15.07	117.77 ± 17.28	114.13 ± 18.83	0.845	0.765	0.991
Total sleep time (min)	296.68 ± 17.77	291.99 ± 15.61	311.33 ± 18.73	304.81 ± 1645	0.535	0.598	0.931
Sleep Efficiency (%)	68.90 ± 4.16	64.31 ± 3.47	70.63 ± 4.38	68.88 ± 3.66	0.539	0.173	0.539
Stage 1 (%)	16.88 ± 2.40	16.89 ± 1.90	18.20 ± 2.54	14.32 ± 2.0	0.814	0.273	0.271
Stage 2 (%)	43.89 ± 2.66	44.45 ± 2.46	43.61 ± 2.80	46.46 ± 2.60	0.798	0.3	0.484
Stage 3 (%)	20.23 ± 2.64	20.98 ± 2.57	22.31 ± 2.78	23.28 ± 2.71	0.527	0.6	0.946
REM (%)	18.77 ± 1.36	17.31 ± 1.59	15.91 ± 1.43	15.94 ± 1.67	0.269	0.498	0.478
Awakenings index (n/h)	18.62 ± 2.44	20.75 ± 1.83	21.03 ± 2.57	15.40 ± 1.92	0.616	0.148	0.002*
Leg moviments (n/h)	25.65 ± 5.80	23.12 ± 6.0	11.92 ± 6.11	12.56 ± 6.32	0.144	0.734	0.57
AHI (n/h)	17.43 ± 3.78	22.97 ± 2.35	19.16 ± 3.99	7.05 ± 2.48	0.087	0.14	0.001*
Apnea index (n/h)	9.45 ± 3.35	12.35 ± 1.88	11.72 ± 3.53	2.90 ± 1.98	0.284	0.16	0.007*
REM Dessat (%)	26.99 ± 4.83	29.65 ± 4.11	27.85 ± 5.09	11.35 ± 4.33	0.163	0.004	0.001*

NREM Dessat (%)	12.94 ± 4.41	18.32 ± 2.89	19.11 ± 4.65	6.25 ± 3.04	0.545	0.137	0.001*

Table 2: Sleep characteristics after intervention.

Data represented as mean ± SD. *p<0,005

AHI: Apnea/Hipopnea índex; REM Dessat: REM Dessaturation and NREM Dessat: NREM desaturation.

Figure 1 shows the effect of training on awakening index, which rose from 21.03 events/h to 15.4 events/h.

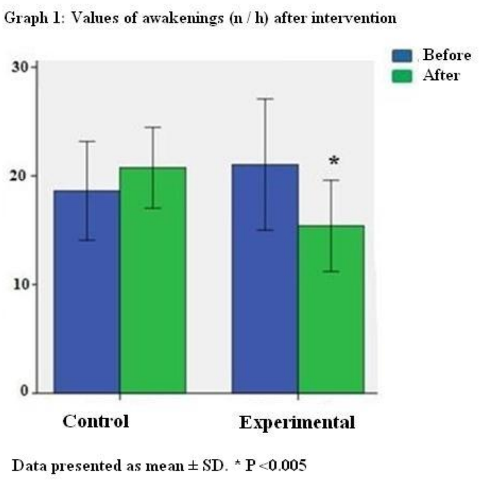

Figure 1: Effect of training on awakening index.

The Figure 2 showed the apnea-hypopnea index where we can observe a large reduction in AHI in the experimental group going from 19.16 events/h to 7.05 events/h.

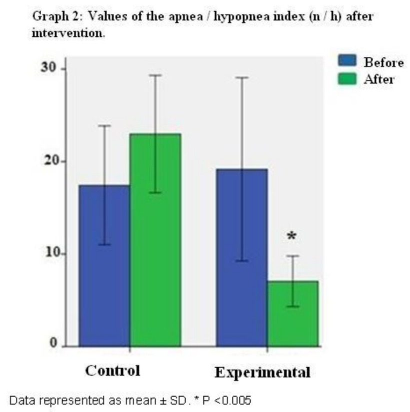

Figure 2: Apnea-hypopnea index.

The desaturation index in REM sleep, decreased from 27.85% to 11.35%, while the desaturation of NREM sleep, decreased from 10.11% to 6.25%, as shown in figures 3 and 4, respectively.

Discussion

We have used the Threshold for 8 weeks and reassess the sleep of the elderly. We note an improvement in the index of apnea and hypopnea, portraying our main finding, since these older adults now have an apnea/hypopnea index considered normal, leading consequently to a reduction in awakenings index and desaturation in REM and NREM sleep. Several studies have tried to propose new strategies for the treatment of sleep apnea syndrome, among them, speech therapists and respiratory treatments of the retraining of the dilator muscles of the pharynx is also arranged, there is an increase in muscle tone which in turn leads to a reduction or elimination of snoring and sleep apnea in all levels, even in severe cases where the continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP) are indicated [22,23]. Other studies have considered the orofacial myofunctional therapy with standardization of posture and breathing exercises as important therapeutic measures. It has been noted an improvement of 40.4/h to 3.3/h AHI, with consequent reduction of awaking and improved oxygen saturation. Breathing exercises practiced by means of wind and singing instruments has also been applied for the treatment of apnea, attesting to both anatomical and biochemical benefits in the reduction of respiratory discomfort [24,25]. It is known that breathing exercises require glottal effort which may impact on the oropharyngeal muscles and maybe this type of exercise can reduce muscle fatigue of apneic patients by improving the oxidative metabolism [25-27].

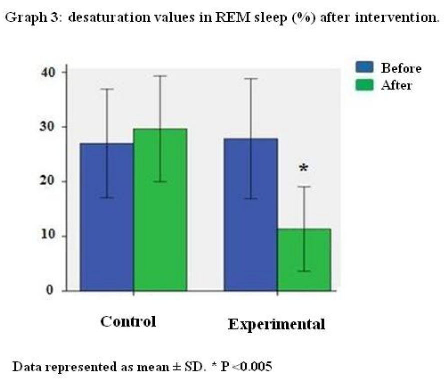

Figure 3: Desaturation index in REM sleep.

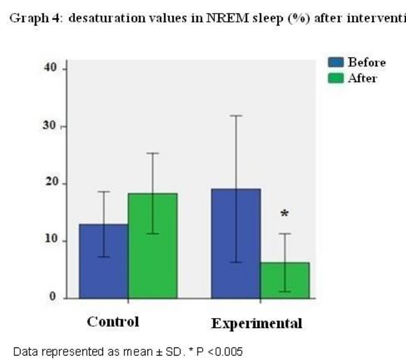

Figure 4: Desaturation index of NREM sleep.

Through these data, we suggest that the Threshold® was able to re-educate the dilator muscles of the pharynx, promotes increased tone of the pharyngeal muscles which in turn led to the reduction or elimination of sleep apnea. The importance of this work lies in the contribution of respiratory exercises in the treatment of sleep apnea, one easily applied therapy with striking effect on the commonly present sleep disorders in the elderly.

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